US009373083B2

(12) **United States Patent**
Shircliff et al.

(10) **Patent No.: US 9,373,083 B2**
(45) **Date of Patent: Jun. 21, 2016**

(54) **BUILDING ANALYTIC DEVICE**

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(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

(21) Appl. No.: **14/831,374**

(22) Filed: **Aug. 20, 2015**

(65) **Prior Publication Data**

US 2015/0356419 A1 Dec. 10, 2015

Related U.S. Application Data

(63) Continuation of application No. 13/873,447, filed on Apr. 30, 2013, now Pat. No. 9,141,912.

(51) **Int. Cl.**
G06N 5/02 (2006.01)

(52) **U.S. Cl.**
CPC . ***G06N 5/025*** (2013.01); ***G06N 5/02*** (2013.01)

(58) **Field of Classification Search**
CPC G06N 5/025
See application file for complete search history.

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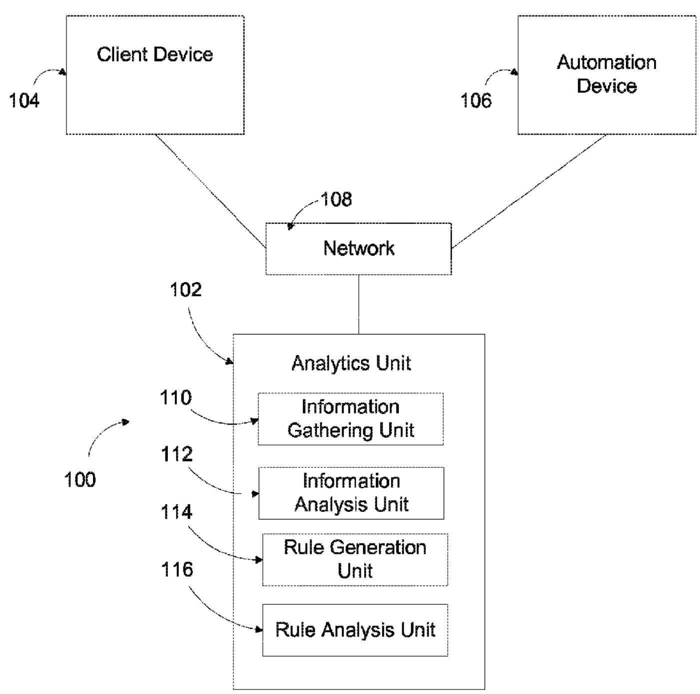
(57) **ABSTRACT**

An information analytic system including an information gathering unit configured to gather at least one piece of information from at least one of a plurality of devices connected to a network, an information analysis unit configured to analyze the gathered information, and a rule generation unit configured to generate at least one rule based on the analysis performed by the information analysis unit. The rule analysis unit is configured to analyze each generated rule to identify the rules that can be applied to the corresponding piece information, and to apply applies the identified rule to the corresponding piece of information. The rule analysis unit is also configured to analyze unapplied rules and to determine what additional information is required to apply each unapplied rule to at least one piece of information.

16 Claims, 7 Drawing Sheets



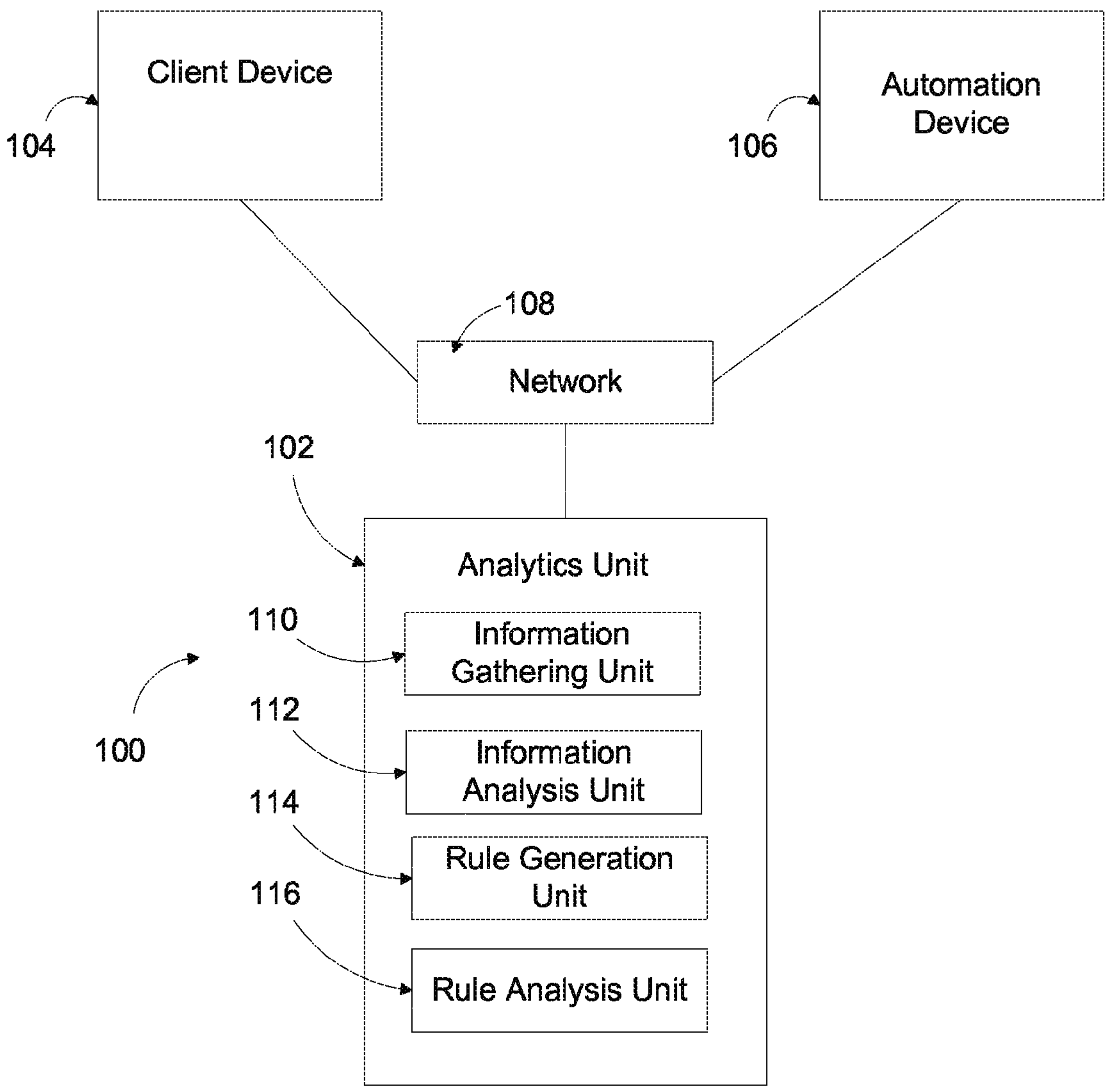
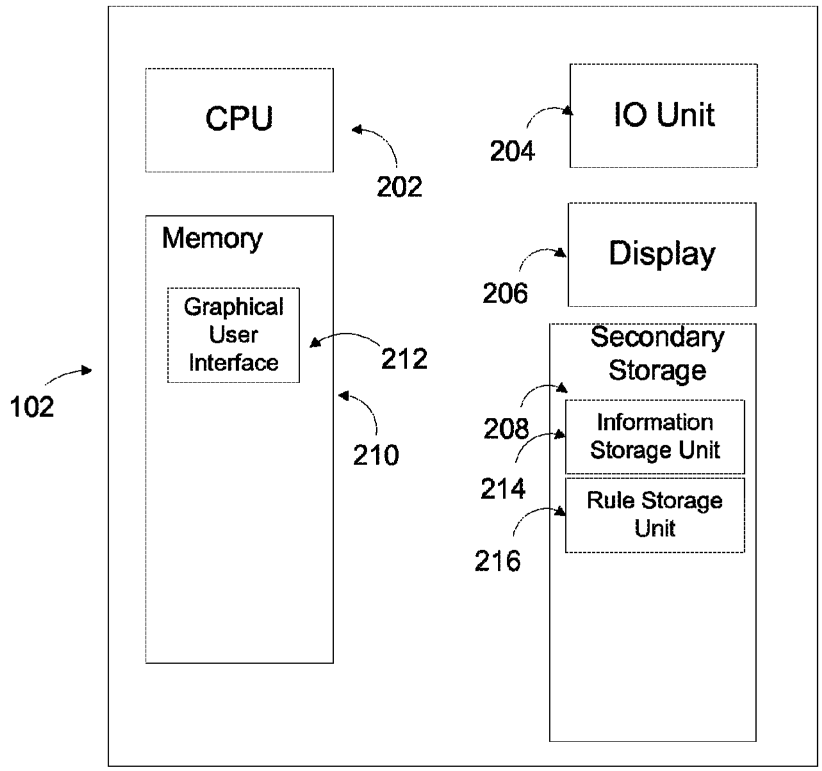
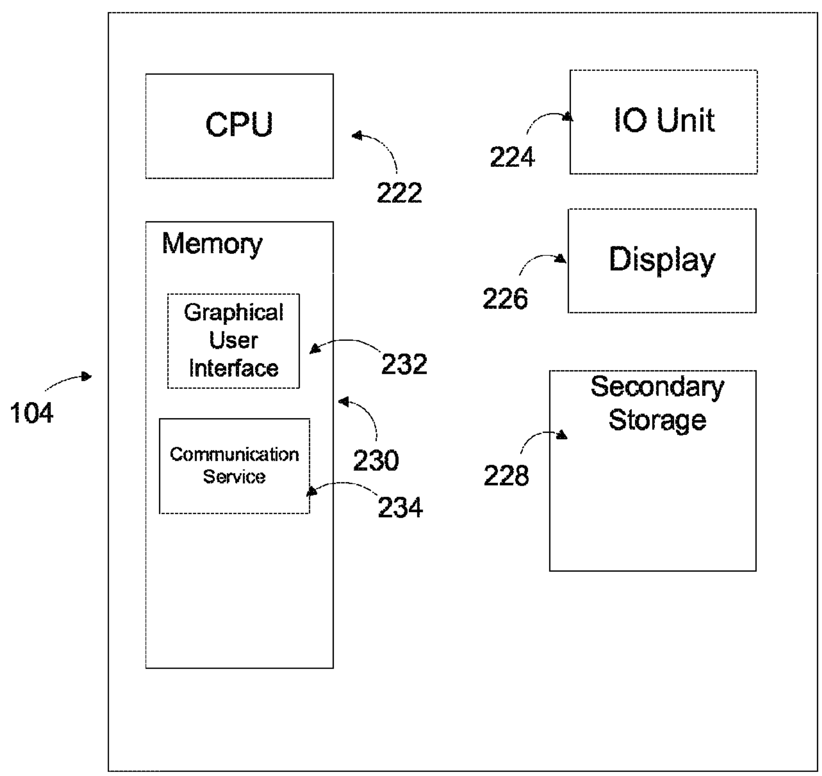

Client Device
104
Automation Device
106
108
Network
102
Analytics Unit
110
Information Gathering Unit
112
Information Analysis Unit
114
Rule Generation Unit
116
Rule Analysis Unit
100

FIG 1



CPU
202
IO Unit
204
Memory
Display
206
Graphical User Interface
212
Secondary Storage
102
208
Information Storage Unit
210
214
Rule Storage Unit
216

FIG 2A



CPU
222
IO Unit
224
Memory
Display
226
Graphical User Interface
232
104
Secondary Storage
230
Communication Service
228
234

FIG 2B

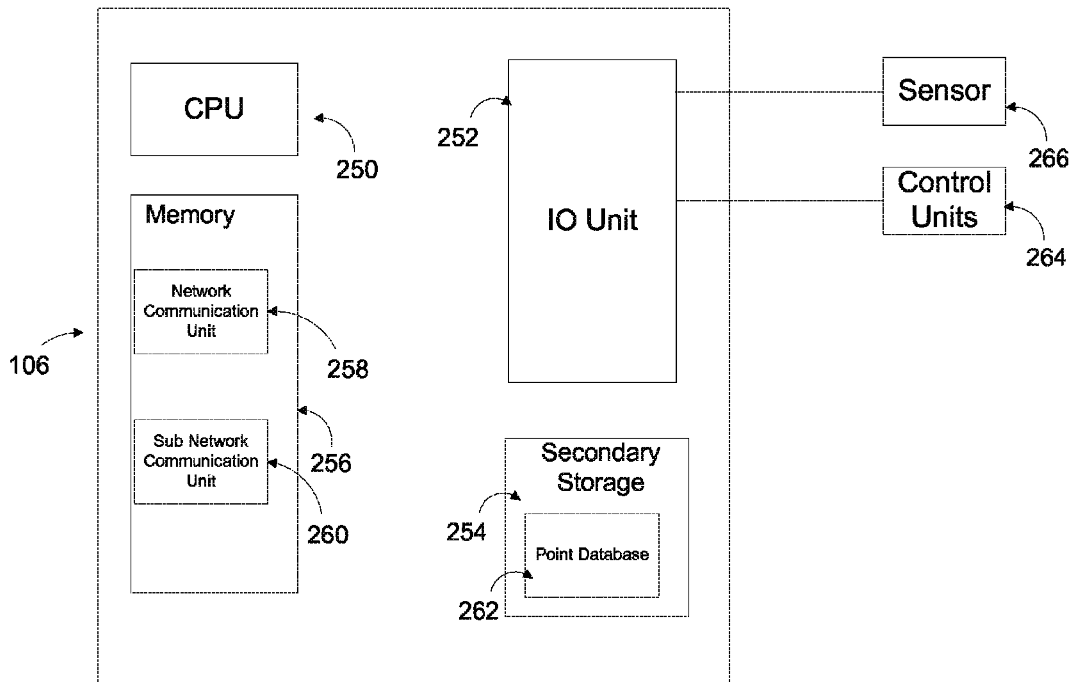

CPU
250
252
IO Unit
Sensor
266
Control Units
264
Memory
Network Communication Unit
258
106
Sub Network Communication Unit
256
260
Secondary Storage
254
Point Database
262

FIG 2C

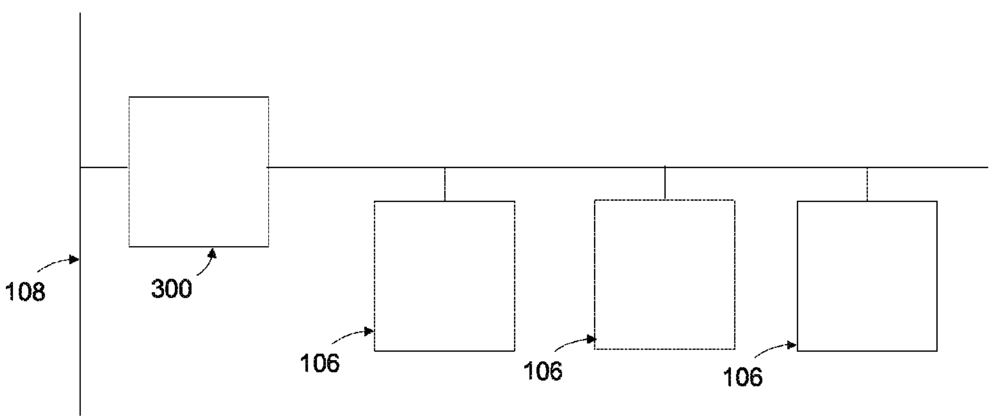

108
300
106
106
106

FIG 3

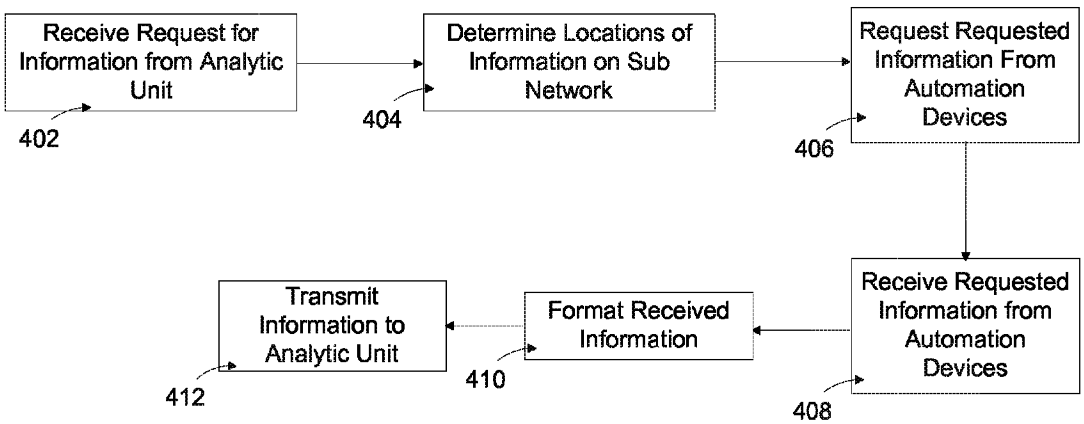

Receive Request for Information from Analytic Unit
402
Determine Locations of Information on Sub Network
404
Request Requested Information From Automation Devices
406
Receive Requested Information from Automation Devices
408
Format Received Information
410
Transmit Information to Analytic Unit
412

FIG 4

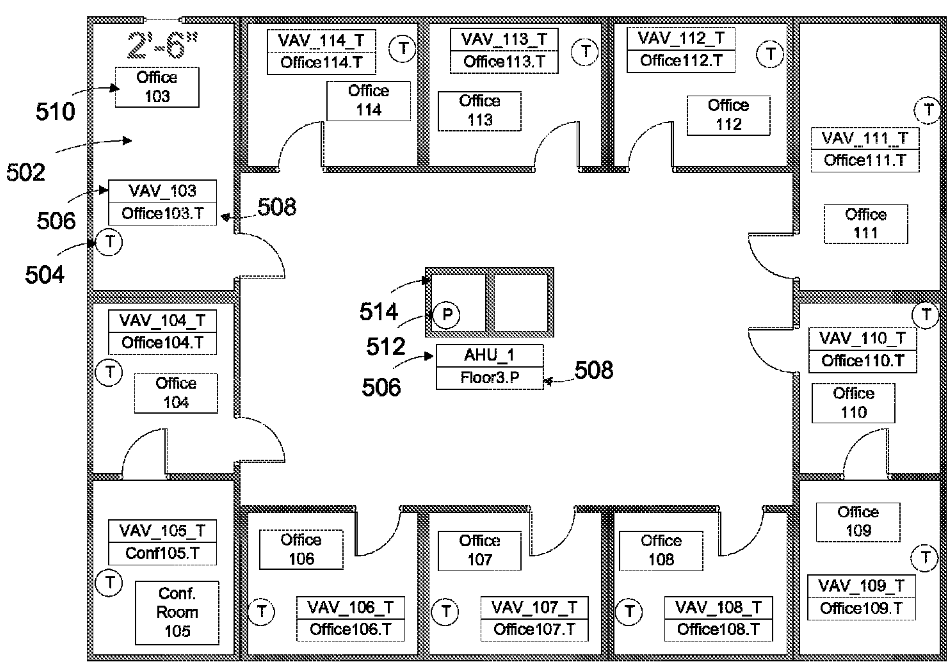

2'-6"
510
502
506
504
508
514
512
506
508
Office 103
VAV_103
Office103.T
VAV_114_T
Office114.T
Office 114
VAV_113_T
Office113.T
Office 113
VAV_112_T
Office112.T
Office 112
VAV_111_T
Office111.T
Office 111
VAV_110_T
Office110.T
Office 110
Office 109
VAV_109_T
Office109.T
Office 108
VAV_108_T
Office108.T
Office 107
VAV_107_T
Office107.T
Office 106
VAV_106_T
Office106.T
VAV_105_T
Conf105.T
Conf. Room 105
VAV_104_T
Office104.T
Office 104
AHU_1
Floor3.P
P
T

FIG 5A

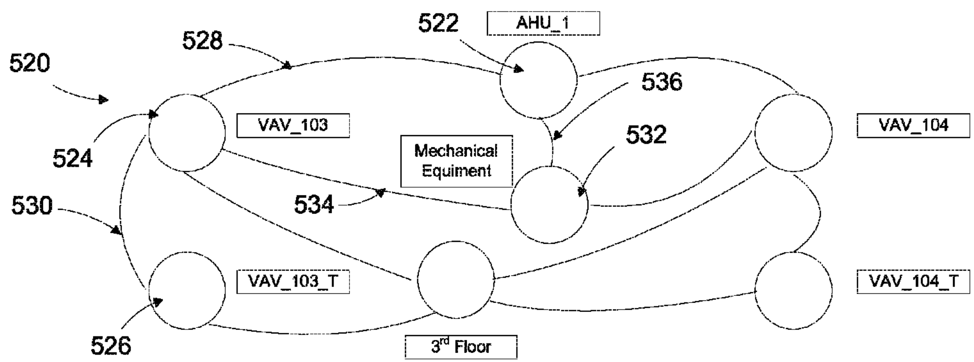


FIG 5B

Point Category	Point Value	Associated Device Type	Associated Point	Associated Point Value
Temperature	> 75 Deg F	Air Handling Unit	Fan Voltage	< 0.5 volts
Pressure	>1.5 inches	Air Handling Unit	Fan Voltage	< 0.5 volts

602 604 606 608 610

600

FIG 6

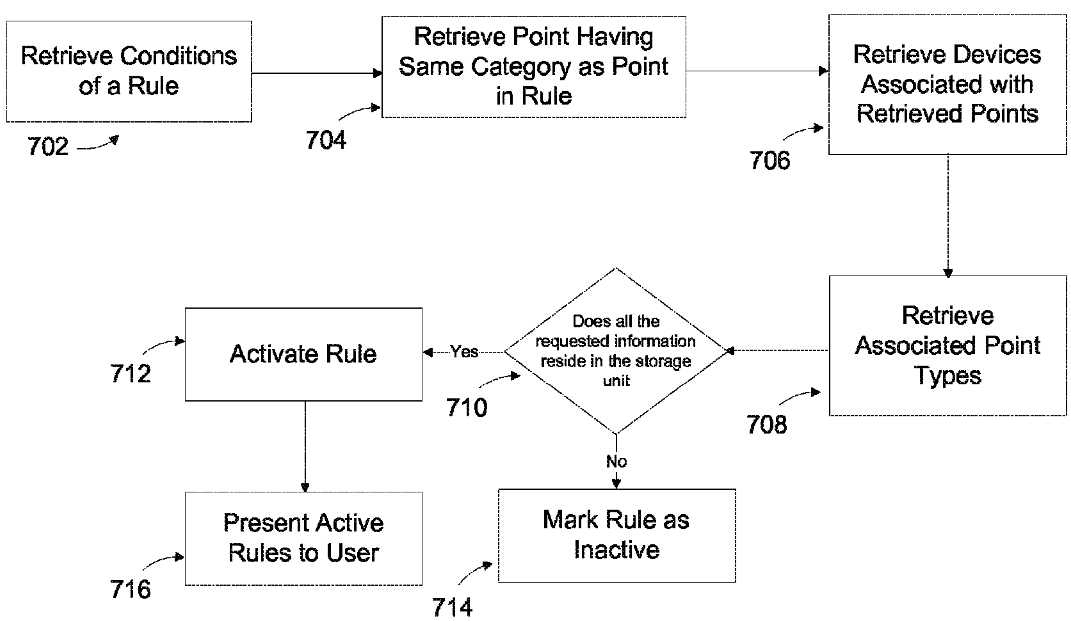


FIG 7

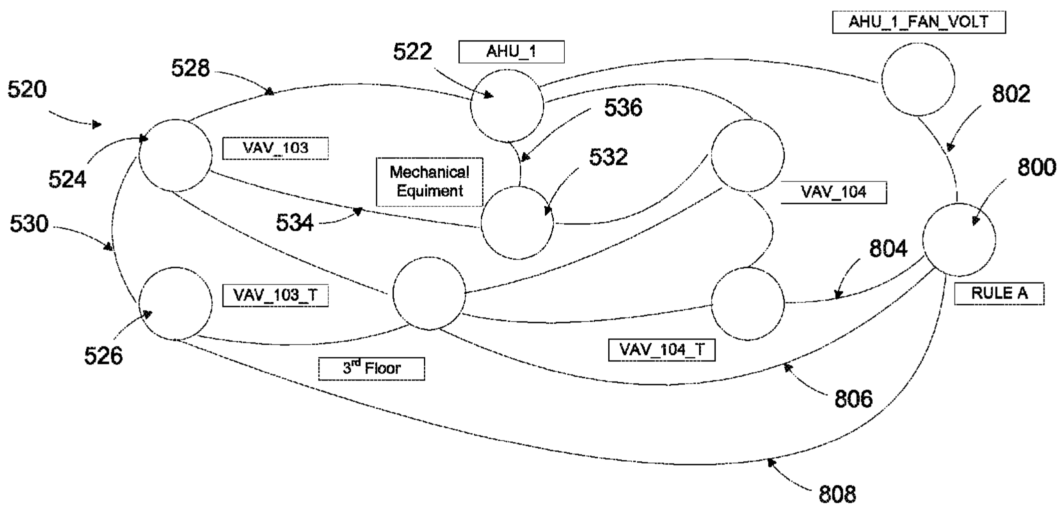

AHU_1_FAN_VOLT
AHU_1
520
528
522
536
802
VAV_103
524
Mechanical Equiment
532
800
VAV_104
530
534
804
VAV_103_T
RULE A
526
3rd Floor
VAV_104_T
806
808

FIG 8A

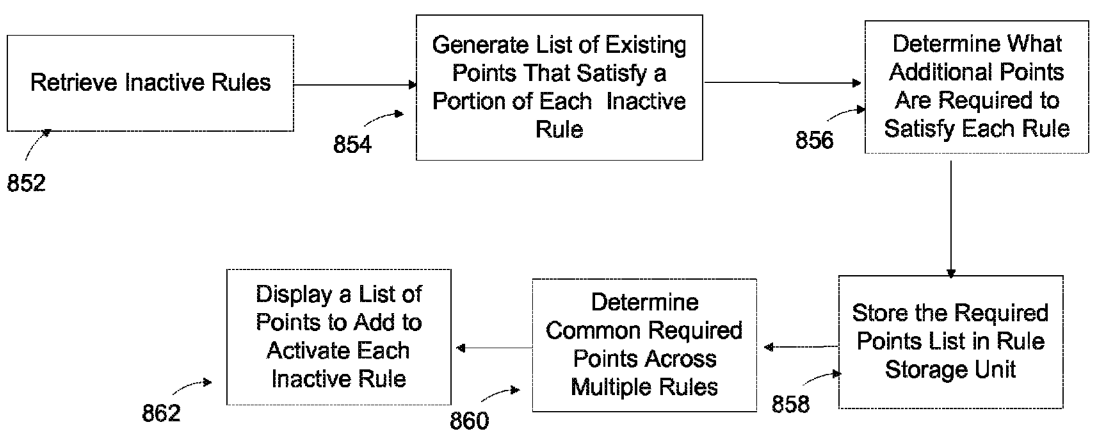

Retrieve Inactive Rules
852
Generate List of Existing Points That Satisfy a Portion of Each Inactive Rule
854
Determine What Additional Points Are Required to Satisfy Each Rule
856
Store the Required Points List in Rule Storage Unit
858
Determine Common Required Points Across Multiple Rules
860
Display a List of Points to Add to Activate Each Inactive Rule
862

FIG 8B

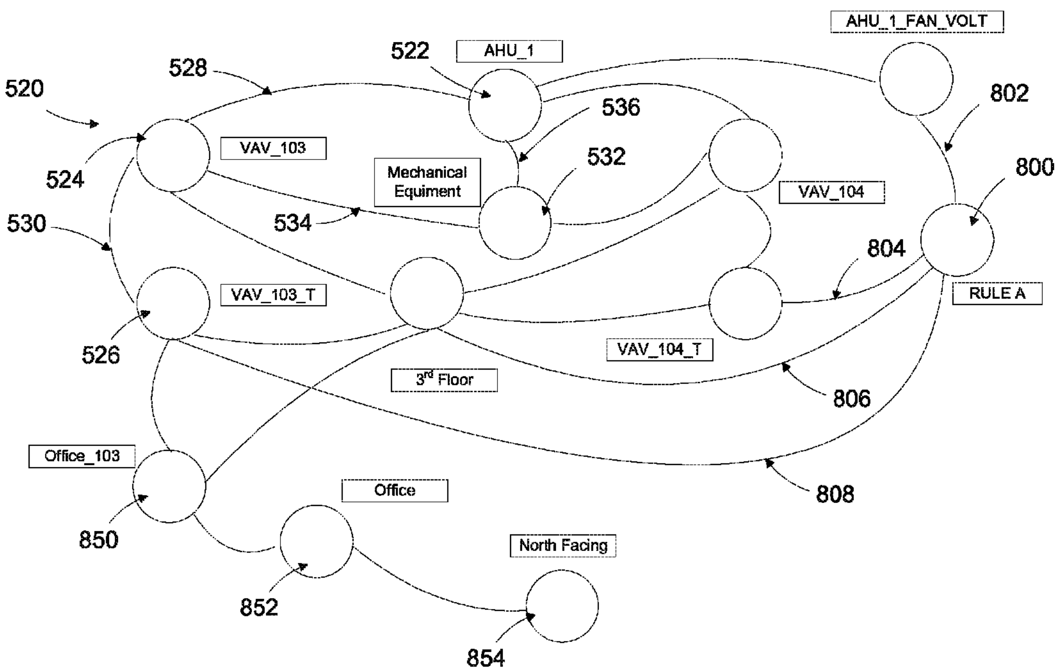

520
528
522
AHU_1
AHU_1_FAN_VOLT
802
536
524
VAV_103
Mechanical Equiment
532
VAV_104
800
530
534
804
VAV_103_T
RULE A
526
VAV_104_T
3rd Floor
806
Office_103
808
Office
850
North Facing
852
854

FIG 8C

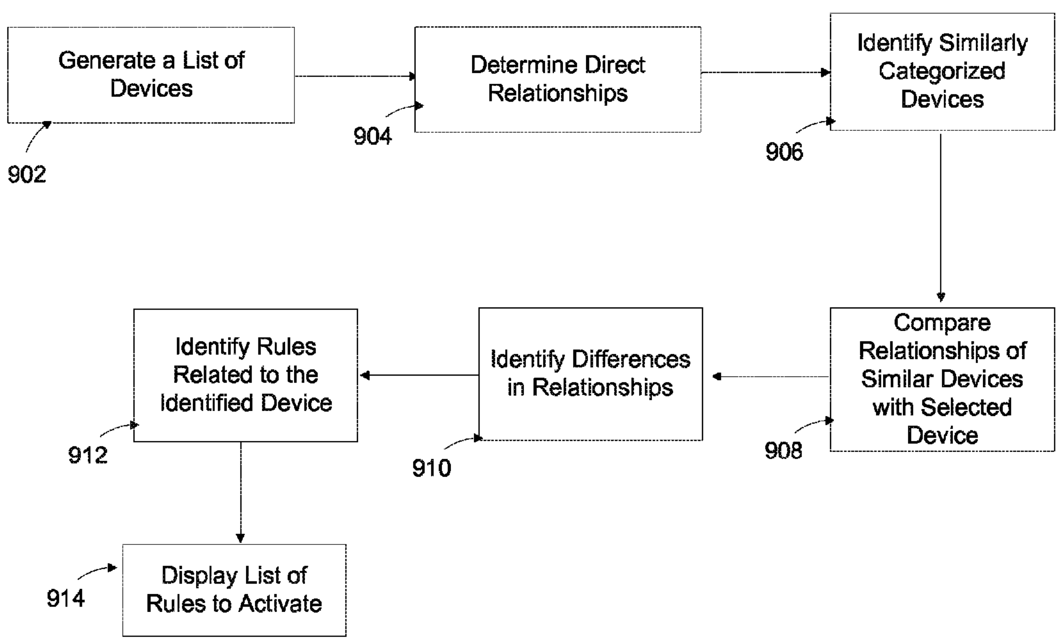

Generate a List of Devices
902
Determine Direct Relationships
904
Identify Similarly Categorized Devices
906
Compare Relationships of Similar Devices with Selected Device
908
Identify Differences in Relationships
910
Identify Rules Related to the Identified Device
912
Display List of Rules to Activate
914

FIG. 9

BUILDING ANALYTIC DEVICE

RELATED APPLICATIONS

This application is a continuation of U.S. application Ser. No. 13/873,447, filed Apr. 30, 2014, titled "Building Analytic Device."

BACKGROUND OF THE INVENTION

Automation systems are used to control different processes and monitor different environmental and operational conditions in a facility. As automation systems have gained wider acceptance, the size and breadth of the environmental and operational conditions monitored has consistently grown. A conventional automation system can monitor and store thousands of conditions.

Because of the expansion in the size of automation systems, analyzing the information gathered by these systems has become difficult. In addition, the complexity of the interaction of different systems operating in facilities has increased the complexity of this analysis. Because of this added complexity, analytical models have been developed to assist in the analysis of the data stored in automation systems. However, these models require a professional, such as an engineer, to review the information stored in the automation system to determine analytical rules that can be applied to the automation system to streamline the operation of the systems in the building.

Many times, the amount of data stored in a building automation system makes the cost of reviewing the information in the automation system impractical. Further, because of the large amount of data to review, many analytical rules that may be implemented are not apparent to the person reviewing the data, and are never implemented. Accordingly, a need exists for a system that can simplify the selection of operational rules based on information provided by an automation system.

SUMMARY OF THE INVENTION

Various embodiments of the present disclosure provide an information analytic system including an information gathering unit configured to gather at least one piece of information from at least one of a plurality of devices connected to a network, an information analysis unit configured to analyze the gathered information, and a rule generation unit configured to generate at least one rule based on the analysis performed by the information analysis unit. The rule analysis unit is configured to analyze each generated rule to identify the rules that can be applied to the corresponding piece information, and to apply the identified rule to the corresponding piece of information. The rule analysis unit is also configured to analyze unapplied rules to determine what additional information is required to apply each unapplied rule to at least one piece of information.

Another embodiment includes an information analysis unit for analyzing information gathered from a network, the information analysis unit includes a memory and a processor that execute an application. The application gathers at least one piece of information from at least one of a plurality of devices connected to the network, analyzes the gathered information, generates at least one rule based on the analysis of each piece of information, analyzes each generated rule to identify each rule that can be applied to a corresponding piece of information, applies each identified rule to the corresponding piece of information, and analyzes each unapplied rule to determine what additional information is required to apply each unapplied rule to at least one piece of information.

Other objects, features, and advantages of the disclosure will be apparent from the following description, taken in conjunction with the accompanying sheets of drawings, wherein like numerals refer to like parts, elements, components, steps, and processes.

BRIEF DESCRIPTION OF THE DRAWINGS

The features and advantages of aspects of the present invention will become more apparent from the detailed description set forth below when taken in conjunction with the claims and drawings, in which like reference numbers indicate identical or functionally similar elements.

FIG. **1** is a block diagram of a building analytic system suitable for use with the methods and systems consistent with the present invention;

FIG. **2**A is a more detailed depiction of the analytic unit included in the analytic system of FIG. **1**;

FIG. **2**B is a more detailed depiction of a user computer included in the analytic system of FIG. **1**;

FIG. **2**C is a more detailed depiction of an automation unit included in the analytic system of FIG. **1**;

FIG. **3** depicts a plurality of automation units connected together on a subnetwork;

FIG. **4** depicts a schematic representation of the analytic unit included in the analytic system of FIG. **1** requesting information from an automation device connected to the network;

FIG. **5**A depicts a floor plan showing an automation system and mechanical system information;

FIG. **5**B depicts the information storage unit of FIG. **2**A storing information in a graph database;

FIG. **6** depicts a user interface that generates a predetermined analytical rule that is stored in the rule storage unit of FIG. **2**A;

FIG. **7** depicts a schematic representation of the rule analysis unit of FIG. **2**A automatically generating a list of rules based on the points stored in the information storage unit;

FIG. **8**A depicts an illustrative example of the rule analysis unit of FIG. **2**A storing rule information in the information storage unit;

FIG. **8**B depicts a schematic representation of the rule analysis unit generating a list of inactive rules that may be cost effectively activated;

FIG. **8**C depicts a schematic of the information storage unit of FIG. **2**A relating the devices to a space in the building; and

FIG. **9** depicts another embodiment of the rule analysis unit of FIG. **1** determining potential inactive rules that may be economically applied.

DETAILED DESCRIPTION

While the present invention is susceptible of embodiment in various forms, there is shown in the drawings and will hereinafter be described a presently preferred embodiment with the understanding that the present disclosure is to be considered an exemplification of the invention and is not intended to limit the invention to the specific embodiment illustrated.

FIG. **1** depicts a block diagram of a building analytic system **100** suitable for use with the methods and systems consistent with the present invention. The building analytic system **100** comprises a plurality of computers **102** and **104** and a plurality of automation devices **106** are shown each connected to one another via a network **108**. The network **108** is of a type that is suitable for connecting the computers **102** and **104** and automation devices **106** for communication, such as a circuit-switched network or a packet-switched network. Also, the network **108** may include a number of different networks, such as a local area network, a wide area network such as the Internet, telephone networks including telephone networks with dedicated communication links, connectionless network, and wireless networks. In the illustrative example shown in FIG. **1**, the network **108** is the Internet. Each of the computers **102** and **104**, and the automation device **106**, shown in FIG. **1** is connected to the network **108** via a suitable communication link, such as a dedicated communication line or a wireless communication link.

Computer **102** may serve as an analytic unit that includes an information gathering unit **110**, an information analysis unit **112**, a rule generation unit **114**, and a rule analysis unit **116**. The number of computers and the network configuration shown in FIG. **1** are merely an illustrative example. One having skill in the art will appreciate that the data processing system may include a different number of computers **102** and **104**, automation devices **106**, and networks **108**. For example, computer **102** may include the information gathering unit **110**, as well as, the information analysis unit **112**. Further, the rule analysis unit **116** may reside on a different computer than computer **102**.

FIG. **2**A shows a more detailed depiction of the analytic unit **102**. The analytic unit **102** comprises a central processing unit (CPU) **202**, an input output (I/O) unit **204**, a display device **206**, a secondary storage device **208**, and a memory **210**. The analytic unit **102** may further comprise standard input devices such as a keyboard, a mouse, a digitizer, or a speech processing means (each not illustrated).

The analytic unit **102**'s memory **210** includes a Graphical User Interface (GUI) **212** which is used to gather information from a user via the display device **206** and I/O unit **204** as described herein. The GUI **212** includes any user interface capable of being displayed on a display device **206** including, but not limited to, a web page, a display panel in an executable program, or any other interface capable of being displayed on a computer screen. The secondary storage device **208** includes an information storage unit **214** and a rule storage unit **216**. Further, the GUI **212** may also be stored in the secondary storage unit **208**. In one embodiment consistent with the present invention, the GUI **212** is displayed using commercially available hypertext markup language (HTML) viewing software such as, but not limited to, Microsoft Internet Explorer®, Google Chrome® or any other commercially available HTML viewing software.

One having skill in the art will appreciate that the information storage unit **214** may be distributed across a different number of computers **102** and **104**, automation devices **106**, and networks **108**. For example, computer **102** may include a portion of the information storage unit **214**, and another computer **102** connected to the network **108** may include another portion of the information storage unit **214**.

FIG. **2**B shows a more detailed depiction of user computer **104**. Computer **104** comprises a CPU **222**, an I/O unit **224**, a display device **226**, a secondary storage device **228**, and a memory **230**. Computer **104** may further comprise standard input devices such as a keyboard, a mouse, a digitizer, or a speech processing means (each not illustrated).

The memory **230** in computer **104** includes a GUI **232** which is used to gather information from a user via the display device **226** and I/O unit **224** as described herein. The GUI **232** includes any user interface capable of being displayed on a display device **226** including, but not limited to, a web page, a display panel in an executable program, or any other interface capable of being displayed on a computer screen. The GUI **232** may also be stored in the secondary storage unit **228**. In one embodiment consistent with the present invention, the GUI **232** is displayed using commercially available HTML viewing software such as, but not limited to, Microsoft Internet Explorer®, Google Chrome® or any other commercially available HTML viewing software.

FIG. **2**C depicts a more detailed depiction of an automation device **106**. The automation device **106** includes a CPU **250**, an IO unit **252**, a secondary storage unit **254**, a memory **256** that includes a network communication unit **258**, and a subnetwork communication unit **260**. The JO unit **252** is communicatively coupled to a plurality of sensors **266** and control units **264**. Each sensor **262** is configured to sense environmental information and transmit the sensed information back to the JO unit **252**. Each control unit **264** is electronically or mechanically coupled to a device such that the control unit **264** converts a signal transmitted from the JO unit **252** into a signal capable of effecting the operation of the device coupled to the control unit **264**. The sensors **266** and control units **264** may be coupled to the JO unit **252** via a wired or wireless connection.

The network communication unit **258** is configured to connect to the network **108**. The subnetwork communication unit **260** is configured to connect to a second network (not shown), or subnetwork, to communicate with other automation units **106**. The subnetwork may be a network operating unit the TIA/EIA-485 protocol, TIA/EIA, 422 protocols, the TIA/EIA 232 protocol, or any other protocol capable of connecting to at least one automation device **106**. The automation device **106** may communicate with other automation devices **106** over the network communication unit **258**, or subnetwork communication unit **260**, using any communication protocol including BACnet, Modbus, LONworks, Fieldbus, CANbus, Profibus, TCP/IP, Ethernet, or any other communication protocol. The automation device **106** may only include the subnetwork communication unit **260** or both the network communication unit **258** and the subnetwork communication unit **260**.

The automation device **106** may be, but is not limited to, a voice over internet protocol (VOIP) phone, a network switching device, a building automation control device, a lighting automation control device, a telephone switching device, an IP camera, a digital video recorder, or any other device capable of communicating over a network.

The automation device **106** may also include a point database **262** stored in the secondary storage unit **254**. A point is defined as any virtual object or real device coupled to the automation device **106**. As an illustrative example, a temperature sensor that is mounted on a wall and wired in to an automation device **106** represents a point. In addition, a variable stored in the memory **256** of the automation device, such as a temperature set point, is also considered to be a point herein.

FIG. **3** depicts a plurality of automation units **106** connected together. The plurality of automation units **106** are communicatively coupled to a master automation device **300**. The master automation device **300** is configured to convert information from the subnetwork for transport over the network **108**. Each of the automation units **106** is configured to gather information on environmental conditions, and to control mechanical and electrical devices that affect the monitored environmental conditions. The master automation device **300** converts requests for information from the network **108** to a format suitable for transport over the subnetwork, and gathers information from the automation units **106** connected to the subnetwork to generate a response to the request.

FIG. **4** depicts a schematic representation of the analytic unit **102** requesting information from an automation device **106** connected to the network **108**. In step **402**, a master automation device **300** coupled to the network **108** receives a request for information from the analytic unit **102**. In step **404**, the automation devices **106** determine the location in the memory **256** of the master automation device **300**, or the location on the subnetwork, where the requested information is stored. In step **406**, the master automation device **300** requests the information from the local memory **256**, or from the automation devices **106** connected to the subnetwork. In step **408**, each automation device **106** on the subnetwork receives the request from the master automation device **300**, and transmits any information related to the request back to the master automation device **300**. In step **410**, the master automation device **300** formats the response based on the requirements of the analytic unit **102**. The format of the response may be based on information received from the analytic unit **102** as part of the request. In step **412**, the master automation device **300** transmits the response back to the analytic unit **102**.

FIG. **5**A depicts a floor plan **500** showing the object name and controller name for each sensor. The floor plan **500** includes a plurality of rooms **502**. Each room includes a temperature sensor icon **504** with an information box **506** positioned next to the temperature sensor icon **504** that indicates an automation device indicator **506** and a point name indicator **508**. Each point name indicator **508** is configured to match a corresponding point name stored in the memory **256** of the automation device **106** as indicated by the device indicator **506**. The device indicators **506** are configured to match the names of the automation devices **106** connected to the master automation device **300**.

Each room on the floor plan **500** also includes a room name indicator **510**. The room name indicator **510** indicates the name, and potentially the use, for each room shown on the floor plan **500**. The floor plan **500** may also include a pressure sensing unit icon **512** positioned in an elevator shaft **514**. The pressure sensing unit icon **512** may include a device indicator **506** and a point name indicator **508**.

The floor plan **500** may be stored in a digital format in the memory **210** of the analytic unit **102**, or the memory **230** of a client device **104**. The digital format may be viewable and editable in a drafting program such as AutoCAD®, provided by AutoDesk Corp. of San Rafael, Calif. The file may also be generated by an building information modeling ("BIM") software package such as, but not limited to, CADMEP by Technical Sales International, or any other BIM software. The drafting and BIM software programs are configured to store information pertaining to the design of a building in different layers of the file. Each layer includes information such as location, operational parameters, dimensions, and other information of equipment depicted in the floor plan. The information analysis unit **112** is configured to extract all information including the room name indicator **510**, device indicator **506**, and point name indicator **508** from each floor plan stored in the floor plan file, and to store the extracted information in the information storage unit **214**.

The information analysis unit **112** may also associate pieces of information extracted from the file together based on the location, operation, physical connection, or logical connections of each piece of information. As an illustrative example referring to FIG. **5**A, the information analysis unit **112** may associate the point Office_103_T with the VAV_103 automation device. The information analysis unit **112** may associate the VAV_103 automation device with a variable air volume (VAV) mechanical unit for room **103** (VAV_103), based on the information extracted from the file. Further the information analysis unit **112** may also determine that VAV_103 is associated with a specific air handling unit (AHU), and associate VAV_103 with the AHU. The information analysis unit **112** may determine the relationships between devices by extracting and analyzing information in the file, such as a schedule of devices, a wiring diagram, a mechanical system flow diagram, or any other data structure in the file that provides information on the relationships between devices on the floor plan.

The information analysis unit **112** may also extract information pertaining to the configuration and relationships of the mechanical and electrical systems in the building. As an illustrative example, the information analysis unit **112** may extract information pertaining to the heating, ventilating and air conditioning systems connected to each room. The information analysis unit **112** may extract the name and location of the AHU connected to office 103 via duct work, and store this information in the information storage unit **214**. The information analysis unit **112** may also create a relationship between each point and a mechanical or electrical device based on the information extracted from the file. The information analysis unit **112** may also be configured to scan the floor plan to identify the different pieces of mechanical and electrical equipment included on each floor plan. Data may be extracted from a drafting program using any known method including exporting the attributes of objects in the drafting program. As an illustrative example, the information analysis unit may extract a listing of all mechanical equipment objects in a drawing along with the attributes for the mechanical equipment. The attributes of each object may be configured to store information pertaining to the relationship of the object to other mechanical devices. As an illustrative example, the VAV_103 object may include attributes such as the connected air handling unit object identifier, control system object name, or any other attribute describing the interconnection between VAV_103 and other systems in the facility.

The information analysis unit **112** may extract the information from a drafting program, such as AutoCAD, and import the information into the information storage unit **214** during initial configuration of the system. The information analysis unit **112** may create objects in the information storage unit **214** corresponding to the points displayed on the floor plan and associate these objects with extracted location indicators and connected mechanical equipment.

The information analysis unit **112** may also extract information pertaining to the configuration and use of each space on the floor plan. As an illustrative example referring to FIG. **5**A, the information analysis unit **112** may extract the dimensions, wall size and thickness, and direction of the windows for each office and store this information in the information storage unit **214**. The information analysis unit **112** may also extract information on the operation of the mechanical and electrical devices on the floor plan.

Once all the information is extracted from the floor plan **500**, the information analysis unit **112** categorizes each point in the information storage unit **214** based on the value of the information, in the case of an input, or the signal the point is generating, in the case of an output. The information analysis unit **112** may categorize each point in the information storage unit **214** by presenting each point to a user of the information analysis unit **102** via the GUI **212**. The information analysis unit **112** may also categorize the spaces defined in the file, such an office or a conference room, along with the characteristics of the space. The characteristics of a space may include the direction the space faces, the dimensions of the space, the operational use for the space, the anticipated or actual occupancy of the space, or any other attribute that can attributed to the space. Further, the information analysis unit **112** may also identify any other data structure from the information and categorizes the identified data structures into predefined categories.

FIG. **5**B depicts the information storage unit **214** storing information in a graph database. A graph database is a known data structure that stores data in a graph structure including nodes, edges, and properties. A graph database allows for the interrelation of different nodes. The information storage unit **214** may incorporate any known graph database including, but not limited to, Horton provided by Microsoft Corporation of Redmond Wash., Neo4j by Neo Technologies, or any other graph database software. The information storage unit **214** may store each piece of information from the floor plan **500** as a node in a graph database. The information analysis unit **112** may also relate each of the nodes together based on physical and logical connections between each node.

Returning to FIG. **5**B as an illustrative example, AHU_1 **522**, VAV_103 **524**, and VAV_103_T **526** are created as nodes in the information storage unit **214**. The information analysis unit **114** logically relates AHU_1 **522** with VAV_103 by edge **528**, because AHU_1 and VAV_103 are physically connected by ductwork. VAV_103_T is logically related to VAV_103 by edge **530**, because VAV_103_T controls the operation of VAV_103. In addition, VAV_103 is logically related to a "Mechanical Device" category **532** by edge **534**, because VAV_103 is a mechanical air control device. AHU_1 is also related to the "Mechanical Device" category **532** because AHU_1 is also a mechanical device. Further, VAV_103 and VAV_103_T are related to a "3rd Floor" category because both devices are physically located on the third floor of the building.

The information analysis unit **112** continues to relate all points entered into the information storage unit **214** based on the physical location of each point, and the mechanical or electrical systems the point monitors or controls. The information analysis unit **112** may extract a list and position of all mechanical devices on the each floor of a building, and relate each mechanical device to points extracted from the file, and to other mechanical devices in the building. The system may perform the same analysis for electrical devices in the building. Further, the system may relate extracted mechanical devices to extracted electrical devices. The system may also assign different attributes to the edges connecting each node. As an illustrative example, for the AHU node, the connecting edges may include model and manufacturer information for the AHU.

FIG. **6** depicts a user interface **600** that generates a predetermined analytical rule that is stored in the rule storage unit **216**. The rule generation unit **114** allows a user to configure predefined rules that are stored in the rule storage unit **216**. A predetermined rule represents a set of conditions that initiate an event when the conditions are satisfied. The user interface allows a user to select a point type **602**, based on the types of points stored in the information storage unit **214**, a point value **604** to initiate an analysis or event, a device type **606** associated with the point category to analyze in connection with point category, another point **608** associated with the associated device category, and a value **610** for the associated point that initiates analysis or an event. FIG. **7** depicts a schematic representation of the rules analysis unit **116** automatically generating a list of rules based on the points stored in the information storage unit **216**. In step **702**, the rule analysis unit **116** retrieves the conditions of a first rule stored in the rule storage unit **216**. In step **704**, the rule analysis unit **116** requests a listing of points consistent with the point type included in the rule. In step **706**, the rule analysis unit **116** determines the points in the listing of points that are associated with the device type of the rule.

In step **708**, the rule analysis unit **116** determines if the device associated with each point includes the associated point type for the rule. In step **710**, the rule analysis unit **226** determines whether the information required by the rule resides in the system. In step **712**, if all the information required by the rule resides in the information storage unit **214**, the rule analysis unit **116** indicates that the rule in the rule storage unit **216** is active, and begins logging the values of the points associated with the rule in the information storage unit **214** over a predefined interval. In step **714**, if all the information required by the rule does not reside in the information storage unit **214**, the rule analysis unit **116** indicates that the rule is inactive in the rule storage unit **216**. In step **716**, the activated rules are display to a user via the GUI **212**.

The information gathering unit **110** generates a list of all points included in the active rules, and requests the values associated with the point names from the automation devices **106** where the points reside. The information gathering unit **110** logs the values returned from the automation devices **106** in the information storage unit **208**. As the point log in the information storage unit **214** is updated by the information gathering unit **110**, the rule analysis unit **116** analyzes the point information stored in the information storage unit **214** based on the rule, or rules, associated with each point, and initiates events when the conditions of any of the associated rules are satisfied. An event may include the generation of a report, email, alarm, or any other type of notification or action.

FIG. **8**A depicts an illustrative example of the rule analysis unit **114** storing rule information in the information storage unit **214**. A rule A is created that monitors the fan voltage on AHU1 and VAV_104_T. The graph database in the information storage unit **214** relates the AHU_1_FAN_VOLT point to the VAV_104_T point by edges **802** and **804** respectively. The information storage unit **214** stores the information in a graph database such that each rule is related to all points associated with the rule. In addition, each rule may be associated with a location in the building or to a specific device. Returning to FIG. **8**A, rule A is also associated with the 3rd floor by edge **806**. Rule A may also be related to VAV_103_T by edge **808**. Accordingly, a single rule may be related to multiple points. The rule analysis unit **116** activates a specific rule based on the relationship between points stored in the database as they apply to the specific rule.

As an illustrative example using the information from FIG. **6**, the rule analysis unit **116** may request a list of all air handling units that are related to a temperature sensor and a fan voltage. The rule will then be applied to all of the related points satisfying this request as previously discussed.

FIG. **8**B depicts a schematic representation of the rule analysis unit **116** generating a list of inactive rules that may be cost effectively activated. In step **852**, the rule analysis unit **116** retrieves a list of inactive rules from the rule storage unit **216**. In step **854**, the rule analysis unit **116** requests a listing of existing points that would potentially satisfy each inactive rule. A point potentially satisfies a rule if it satisfies any of the category requirements of the rule. Using FIG. **6** as an example, a temperature sensor related to an air handling unit would potentially satisfy a portion of the first rule in the list of FIG. **6**.

In step **856**, the rule analysis unit **116** analyzes each rule to determine what additional point information is required to satisfy a remaining portion of each rule. In determining that additional point information required to satisfy a rule, the rule analysis unit **116** may compare the point categories associated with the points categories in the rule to determine if the all of the point categories of the rule exist in the system for each device. As an illustrative example, the rule analysis unit **116** may compare the point categories for a first rule with the point categories associated with a specific air handling unit. If the air handling unit being analyzed does not include a point category in the rule, the rule analysis unit **116** identifies the missing category and associates the missing point category with the air handling unit being analyzed.

In step **858**, the rule analysis unit **116** stores the required points list in the rule storage unit **216** along with the required location and/or required device connections for each point. Referring again to FIGS. **5**A and **6**, if the fan voltage on AHU_1 is not installed, the rule analysis unit **116** would identify the fan voltage on AHU_1 as a missing point that is required to satisfy the first rule in FIG. **6**. The rule analysis unit **116** would also determine that adding a fan voltage sensor to AHU_1 would allow for the activation of the first rule in FIG. **6** for VAV_103.

In step **860**, the rule analysis unit **116** determines the points on different devices that are common to multiple rules. Because the required points are stored in a graph database that relates the points to devices and locations, the rule analysis unit **116** can generate a list of rules that can be activated by adding a single point. As an illustrative example referring to FIGS. **5**A and **6**, the first rule in FIG. **6** requires AHU_1 have a fan voltage to be implemented. The addition of a fan voltage on AHU_1 would allow for the activation of the first rule in FIG. **6** in relation to VAV_103 to VAV_114. In addition, the addition of the fan voltage on AHU_1 will also allow for the activation of the second rule in FIG. **6** in relation to the 3rd floor. Accordingly, the addition of a single point can have a very large impact on the number of activated rules.

In step **862**, the rule analysis unit **116** may display a listing of missing points to add on each system, and the associated rules that may be activated by the addition of the points. The rule analysis unit **116** may configure the displayed information such that a user can view the number of rules that may be activated by adding a missing point to a specific device. Accordingly, the user is able to determine the impact of adding additional points to the automation system. The report may also generate an estimated cost to add each missing point, and the projected economic impact of the activation of each rule. The cost estimation may be performed using known estimating techniques, such as allocating a cost based on the point type, or any other estimating method.

The rule analysis unit **116** may also determine the cost savings associated with implementing a rule. The cost savings may be generated based on historical information from similar facilities that is stored in the information storage unit **214**. The rule analysis unit **214** may also calculate the estimated time required to generate enough savings to pay the cost of installing an additional point.

The rule analysis unit **116** may assign a cost saving equation to each rule or device stored in the information storage unit **214**. The cost saving equation may be related to the overall operation of a single device or multiple devices. Each cost saving equation may also be stored and associated with an individual device. As an illustrative example, a fan in an air handing unit may be assigned the following cost estimate equation: Cost Savings=0.745699872(Fan Horsepower)*(1 hour)*(Cost per kilowatt-hour). where the fan horsepower and cost per kilowatt hour are stored in the information storage unit **214**. The rule analysis unit **116** may assign cost saving values to each rule in the in the information storage unit **214**. Returning to the example, the rule analysis unit **116** may assign a value of minus one (1) hour of operation per day to a rule associated with the fan in the air handling unit, which represents a reduction of one (1) hour to the total daily operation of the fan if the rule is implemented. The value may be inputted by an end user or may be estimated based on data stored in the information storage unit **214**.

To determine the cost savings to implement a rule associated with the air handling unit, the rule analysis unit **116** calculates the cost savings using the equation above to determine the cost of operation of the fan for one hour. The rule analysis unit **214** then calculates the number for fewer hours the fan would operate when the rule is implemented. The number of fewer of hours may be determined by examining schedules associated with the air handling unit that are gathered by the information gathering unit **110**. The information may also be inputted by a user into the rule analysis unit **116**. Returning to the illustrative example, if the fan is 50 horsepower and would operate for 1 hour less per day (the −1 value) and the fan operates 365 days per year, the total savings at 0.07 cents per kilowatt would be calculated as:

Cost Savings=0.745699872(50 hp)*(1 hour)*(0.07 cents/KWh)*(365 hours)=$952.63 per year.

The rule analysis unit **116** may display the estimated yearly cost savings of implementing the rule on the GUI.

The rule analysis unit **116** may also assign cost savings resulting from a reduction in maintenance, better operational efficiencies, and reduced operation of other related systems for each rule. Each additional cost savings reduction may be assigned to each rule and calculated using information stored in the information storage unit **214** or gathered from a user. While the example above illustrates the calculation of savings for a fan, the rule analysis unit **116** may determine cost savings for any rule by utilizing cost saving equations and information stored in the information storage unit **214**.

FIG. **8**C depicts a schematic of the information storage unit **214** relating the devices to a space in the building. As an illustrative example, Office_103_T **526** is associated with the Office 103 **850** on the floor plan in FIG. **5**A. Office 103 **850** is also related to the office category **852** indicating that the space is used as an office, and the North Facing **854** category indicating that the Office 103 faces north. The information analysis unit **112** may also relate Office 103 **850** to other attributes associated with an office including occupancy of the office, the materials used to construct the room, or any other attribute of the office or the building. Each office node may also be related to other office nodes by floor or quadrant of a floor. Accordingly, point, mechanical device, electrical device, and space information can be interrelated in the information storage unit **214**.

FIG. **9** depicts another embodiment of the rule analysis unit **116** determining potential inactive rules that may be economically applied. The rule analysis unit **116** may identify typical relationships between devices, points, and space information to determine the likelihood that a particular rule would be applied to a point or points. As an illustrative example, the rule analysis unit may identify the Office_103_T as being a space temperature sensor that is associated with office 103, the office 103 being associated with an office category, and the attribute north facing. The Office_103_T may also be associated with the 3rd floor category and to VAV_103 **524**.

Returning to FIG. **9**, in step **902**, the rule analysis unit **116** generates a list of devices, and selects a first device for analysis. In step **904**, the rule analysis unit **116** determines each direct relationship for the selected device by querying the information storage unit **214**. In step **906**, the rule analysis unit **116** identifies devices in the information storage unit **214** that are related to the same, or substantially similar, categories. In step **908**, the rule analysis unit **116** compares the relationships of the identified devices with the relationships of the selected device. In step **910**, the rule analysis unit **116** identifies relationships the identified device has established that are not established with the selected device. In step **912**, the rule analysis unit **116** identifies rules related to the identified device that utilize the relationships identified in step **910**. In step **914**, the rule analysis unit **116** displays a listing of inactive rules that are activated for similar devices. The display may also present a listing of points that must be installed to initiate the rule.

The rule analysis unit **116** may also determine the frequency with which a rule is related to each identified device. As an illustrative example, if a rule is applied to half of the devices identified in step **906**, the rule analysis unit **116** may display the rule along with an indication that 50% of similar devices activate the rule.

The rule analysis unit **116** may perform the same analysis performed in FIG. **9** using a space identifier or point identifier in place of the device. As an illustrative example, the rule analysis unit **116** may determine the relationships attached to a specific room type and generate a list of rules based on the rules applied to similar room types.

The rule analysis unit **116** may also present the rules used by a system on a GUI where users may rate the effectiveness of each rule. Further, the rule analysis unit **116** may analyze comments made by users on the implementation and effectiveness of each rule and utilize the gathered comments to rate each rule. As an illustrative example, the rule analysis unit **116** may generate a list of all active and inactive rules and present the rules in a list displayed on a GUI. A user can then view each rule and assign an effectiveness value to each rule based on the rule's effectiveness at the user's facility. Further, a user may interact with other users to generate conditions for implementing a specific rule, the information required to implement a specific rule, or modifications of a specific rule that may enhance the operation of the rule. The rule analysis unit may be configured to create new rules, or adjust existing rules, based on the comments, and additional information, provided by users.

In the present disclosure, the words "a" or "an" are to be taken to include both the singular and the plural. Conversely, any reference to plural items shall, where appropriate, include the singular.

From the foregoing it will be observed that numerous modifications and variations can be effectuated without departing from the true spirit and scope of the novel concepts of the present invention. It is to be understood that no limitation with respect to the specific embodiments illustrated is intended or should be inferred. The disclosure is intended to cover by the appended claims all such modifications as fall within the scope of the claims.

The invention claimed is:

1. An information analytic system including:

a plurality of automation units each connected to a plurality of monitoring and control devices and connected to a network and configured to collect environmental information;

a facility information unit connected to the network and configured to store information relating to locations of devices related to the facility;

an information gathering unit connected to the network and communicatively coupled to at least one of the automation units and the facility information unit that retrieves a listing of all monitoring and control devices connected to each automation unit and relates each monitoring and control device to at least one device in at least one facility;

an information analysis unit that analyzes the information from the facility information unit and logically relates the devices in the facility based on physical connections between the devices: and

a rule analysis unit that analyzes the control and monitoring devices connected to each automation unit and selects a listing of rules from a predetermined listing of rules based on the control and monitoring devices connected to the automation units.

2. The information analytic system of claim **1**, wherein the rule analysis unit selects a listing of rules based on the relationships between the devices in the facility.

3. The information analytic system of claim **2**, wherein the rule analysis unit identifies a plurality of potential rules from the listing of identified rules based on the devices connected to the automation units.

4. The information analytic system of claim **3**, wherein the rule analysis unit identifies additional devices to connect to the automation units in order to apply at least one potential rule.

5. The information analytic system of claim **4**, wherein rule analysis unit determines a cost associated with connecting the additional control and monitoring device.

6. The information analytic system of claim **5**, wherein the rule analysis unit determines a cost savings associated with applying a potential rule based on information from the facility unit on the operation of the device associated with the additional control and monitoring device.

7. The information analytic system of claim **5**, wherein the rule analysis unit determines if additional automation units are required to connect the device based on the information from the facility unit.

8. The information analytic system of claim **1**, wherein the automation units include at least one building automation unit.

9. A method of applying a rule including steps of:

gathering information from a plurality of automation units each connected to a plurality of monitoring and control devices and connected to a network and configured to collect environmental information and a facility information unit connected to the network and configured to store information relating to locations of devices related to the facility;

retrieving a listing of all monitoring and control devices connected to each automation unit;

relating each monitoring and control device to at least one device in at least one facility; and

analyzing the information from the facility information unit and logically relates the devices in the facility based on physical connections between the devices:

analyzing the control and monitoring devices connected to each automation unit and selecting a listing of the rules from a predetermined listing of rules based on the devices connected to the automation units.

10. The method of claim **9**, including the step of selecting listing of rules based on the relationships between the devices in the facility.

11. The method of claim **10**, including the step of identifying a plurality of potential rules from the listing of identified rules based on the devices connected to the automation units.

12. The method of claim **11**, including the step of identifying additional devices to connect to the automation units in order to apply at least one potential rule.

13. The method of claim **12**, including the step of determining a cost associated with connecting the additional control and monitoring device.

14. The method of claim **13**, including the step of determining a cost savings associated with applying a potential rule based on information from the facility unit on the operation of the device associated with the additional control and monitoring device.

15. The method of claim **13**, including the step of determining if additional automation units are required to connect the device based on the information from the facility unit.

16. The method of claim **9**, wherein the automation units include at least one building automation unit.

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